REPRESENTING VIDEO CLIPS OF STUDENTS' THINKING IN A MATHEMATICS CLASSROOM AS ANIMATIONS

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Video clips and animations have been used to encourage discussions of teaching in professional development. While both representations are useful for teacher noticing of students' thinking, animations may be more viable for sharing with a wider audience. We describe a process for representing a video clip of students' thinking as an animation which preserves the focus on students' actions by using the cK¢ framework and video clip selection criteria. We found two types of clips, explaining clips and working clips. We address challenges with explaining clips where students did not provide enough verbal evidence of their thinking, and challenges with working clips where students worked on different conceptions at the same time. This study is relevant for designers of professional development who wish to increase the uses of a classroom video clip and broaden the set of resources available for promoting teacher learning.

Keywords: Design Experiments, Teacher Education-Inservice/Professional Development, Technology

Introduction

Teacher professional development has used both discussions of videos and animations to help teachers notice students' thinking (e.g. Chieu, Herbst, & Weiss, 2011; van Es & Sherin, 2010). When teachers study videos from their own classrooms with other teachers, they can develop a better understanding of their own practices (Borko et al., 2008). However, using video clips recorded in the classroom of a practicing teacher can create challenges because it is important to maintain a stance of critical inquiry while also supporting teachers (Lord, 1994). In addition, compliance with protocols that require protecting the identity of study participants can limit the availability of video to a wider audience, especially when scaling up a professional development intervention, While animations have been used in the past as a way to design stories of classroom instruction (Herbst, Nachlieli, & Chazan, 2011), they also have potential to allow professional developers to show examples of actual students' thinking using a different representation than a video clip. Representing a video clip as an animation could allow professional developers to show the representation to a wider audience and provoke teacher noticing of student thinking differently. In this paper, we describe a process we used to represent video clips of students' thinking as animations while attempting to preserve the nature of the original video clip, and how we addressed challenges with the differences in the representations.

Using Video and Animations in Professional Development

Video Clips

Video clips of actual mathematics classroom instruction are a popular tool in teacher professional development (e.g. Borko et al., 2008; Coles, 2013; Sherin & van Es, 2005). One use of video clips is a video club (Sherin & Han, 2004), where teachers gather to watch a video clip of students' work in one of their own classrooms and identify and discuss the students' thinking. In a typical video club, the focus is on using evidence found in the video clip to identify what the student was thinking (van Es & Sherin, 2010). Video clubs have been shown to encourage teacher growth in focusing on student thinking over teacher moves (Sherin & Han, 2004), interpreting rather than evaluating students' actions (Sherin & van Es, 2005), and using evidence to back claims about students' thinking

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(Sherin & van Es, 2005). The video clip is typically around five minutes in length (Sherin & van Es, 2005), and can be of whole class discussion (e.g. Sherin & van Es, 2005), group work (e.g. Borko et al., 2008), or students' work at the board (van Es, 2009). It is important that the video must highlight something mathematically interesting in the class (van Es, 2009).

Animations

Animations have also been used to encourage teachers' discussions in professional development. One example of the use of animations is the ThEMaT project (Herbst & Chazan, 2003), which uses animations to provoke teachers' discussions of what is typical in mathematics instruction by showing interactions that deviate from the norm. Outside of mathematics education, animations have also been used to promote character education (Bailey, Tettegah, & Bradley, 2006) and teach classroom management to pre-service teachers (Smith, McLaughlin, & Brown, 2012). While a goal of the use of animations is to encourage teacher learning (Chieu, Herbst, & Weiss, 2011; Nachlieli, 2011; Smith, McLaughlin, & Brown, 2012), a contrast with video clips is that animations can be designed to showcase specific aspects of teaching (Herbst & Chazan, 2006). Researchers have described additional benefits of animations as the ability to abstract a case so that teachers could identify with it as their own classroom and students by removing distinctive physical features from the classroom and animated characters (Chazan & Herbst, 2012; Herbst & Chazan, 2006). Overall, animations allow for the intentional design of specific cases of instruction in a way that can be presented to teachers in a generalized setting.

Comparing Videos and Animations

Researchers have found that teachers are able to discuss and analyze classroom interactions across multiple representations of teaching (Herbst & Chazan, 2006; Smith, McLaughlin, & Brown, 2006). When pre-service teachers were shown either a 3-D computer animation or a live action video of a classroom management scenario, there was no difference found in teachers' analysis (Smith, McLaughlin, & Brown, 2006). Herbst and Chazan (2006) found that, though teachers did remark on differences in the temporality of events when shown stories of teaching as animations, comic books, and slide shows, they still were able to discuss the stories as if they were real episodes from a classroom. In addition, while they found differences in the types of statements made, Herbst and Kosko (2014) found that animations and video were equally useful for eliciting teacher evaluations. Research comparing teacher reactions to video clips and animations suggests that animations are a valid representation of students' thinking when using video clips is not viable.

Research Questions

Because teachers have the ability to notice similarly when analyzing video clips and animations (Herbst, Aaron, & Erickson, 2013), and animations make it feasible to share video clips with a wider audience as previously described, we designed a process for representing video clips of students' thinking as animations and addressing challenges that we encountered during that process. Specifically, we wish to address the following questions:

1. How can a video clip be made into an animated vignette while preserving the nature of the original representation?
2. What challenges arise when creating an animated vignette from a video clip of students' thinking?

Because the animations we created were slides with voice-recorded dialogue, we could not create an exact replica of the original video clip with animated characters. However, we wanted the experience of watching the animations to be as close as possible to the experience of watching the original video clips. The first question addresses how we created a process that would allow us to

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represent video clips as animations with slides and dialogue while maintaining the same criteria of the video clip that caused us to identify it as worthwhile. However, we found challenges in the process both with how to represent entire clips and with individual aspects of the clips. The second question discusses what challenges we encountered and how we addressed those challenges.

Theoretical Frameworks

cK¢ Framework

We used the cK¢ framework (Balacheff, 2013) to understand how students were thinking during the video clips. The cK¢ framework examines students thinking in terms of conceptions, which are composed of a problem which a student attempts to solve with a series of operations, using a set of semiotic resources, and verifying with a control structure (Balacheff, 2013). The cK¢ framework was useful for the analysis of the video clips because identifying the students' conceptions was a key purpose of viewing and discussing the original video clips. By analyzing the clips with a focus on each student's conceptions, we could ensure we represented the video clip as an animation in a way that preserved each of the original conceptions.

Criteria for Criticizing Video Clips

After we identified the students' conceptions using the cK¢ framework, we used the criteria of *window*, *depth*, and *clarity* defined by Sherin, Linsenmeier, and van Es (2009) to analyze how to represent the video clips as animations. The first criteria, *window*, refers to how well the clip affords the viewer an opportunity to determine what the student is thinking, while *depth* refers to how substantive the student's ideas are, and *clarity* refers to how well one can determine the student's thinking from the video clip (Sherin, Linsenmeier, & van Es, 2009). Because the depth of the students' ideas was dependent on the actual student operations, and not how they were represented, we did not consider the depth of the student idea when deciding how to represent the video as an animation. However, understanding the window into students' thinking for each conception and the clarity of the conception provided a framework for preserving the nature of each video clip when representing it as an animation.

Methods

Data for the project comes from video recorded in the classrooms of five Geometry teachers in high-needs schools that participated in a two-year professional development study group funded by the National Science Foundation, focusing on noticing and using students' prior knowledge. Video clips used in this paper were recorded only during the first year of the professional development, and were used for video club discussions during the professional development study group sessions. The animations to be created were a series of still frames of students working at a small group, with scripted audio. Because the original video clips were determined to be worthwhile examples of student thinking by the framework of window, depth, and clarity described by Sherin, Linsenmeier, and van Es (2009), and we desire to compare the video and animated representations of the classroom interaction, our goal was to maintain the nature of the original video clip as much as possible.

In order to design the animations, we first developed a template, using the students' conceptions framework by identifying the operations that students performed and semiotic resources used (Balacheff, 2013) in the video. We viewed the video in order from start to finish, coding each conception with corresponding operations and semiotic resources. To address the need to create both audio and visual slides for the animations, we described in the template what visual and verbal evidence demonstrated the students' operations for each conception. We then used the operations, semiotic resources, and evidence to decide what should be included in the animated version of the video clip. We will discuss this process further to answer the first research question.

Results

Designing a Process to Preserve the Nature of the Original Video Clip

When using the template to recommend how to represent the video clips as animations, the central question we asked for each student operation was how to represent that operation to retain the window into students' thinking while not affecting the clarity. In order to do so, we examined the verbal and visual evidence shown by the student for each operation. Then, we asked if the window into students' thinking changed without the visual evidence. If it did not, we did not need to make a new slide for that operation, and relied on the script to represent the student's idea. If it did, we decided what needed to be added to the animation. Our guidelines were to preserve the script if possible, and write a recommendation for a slide to show the visual evidence. Figure 1 shows a flow chart of our process.

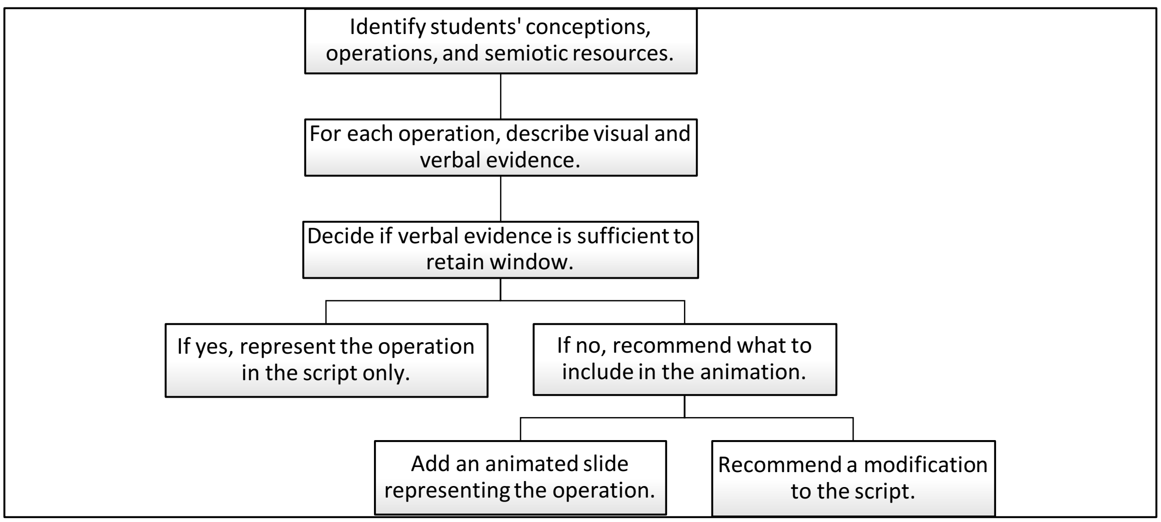

Figure 1. Flow chart of the video to animation process.

As an example of the video clip to animation process, Table 1 shows the template for a video clip of students working on a problem about dilation in the context of one-point perspective. The students are given a diagram with a vanishing point, two houses drawn to be the same size in one-point perspective on the right, and two trees drawn to be different sizes in one-point perspective on the left. In this specific video clip, the students are examining the figure in order to determine which tree is larger.

Table 1: Example of the video to animation template

Student	Description	What is visible at the beginning of the conception	Time Code Video	Operations	Semiotic Resources	Verbal evidence	Visual evidence	Is visual evidence needed?	Necessary evidence to retain window	Recommended modification
Stephanie	The front house is missing a line.	Students' worksheets with answers for question 1	0:40	Describe that she doesn't like the missing line.	Worksheet, pencil as pointing device	She says she doesn't like that there's a line missing	Pointing (missing line)	Yes	Where is the missing line	Slide: Show the paper with Stephanie pointing to the missing line.
Cassie	Use appearance to decide the larger tree	Same as before	0:58	Use appearance to determine the front tree is larger.	Worksheet, finger as pointing device	"But this tree does seem bigger than this one."	Pointing (trees)	Yes	Which tree looks bigger	Script: Replace "this tree" with "the front tree"
Stephanie	Use where the perspective line crosses the tree to decide which is larger.	Same as before	1:00	Examine where the perspective line crosses each tree.	Worksheet, finger as pointing device	"But if you look at it where this line crosses and it crosses right there it gets smaller."	Pointing (intersection of perspective lines and trees)	Yes	What intersections she is examining	Slide: Stephanie pointing to the perspective line crossing the larger tree.
				Determine the trees are the same size because of how the line crosses.		"I am saying yes because they are on the same vanishing point thing."	None	No	None	
				Write her answer on her paper.		None	None	No	None	
Stephanie	Determine what to call the lines.	Same as before	1:30	Ask what to call something on her paper.	Worksheet, pencil as pointing device	"What would you call this? Because that is the vanishing point."	Points to the vanishing point	Yes	What is she determining the name of	Slide: Stephanie pointing to the vanishing point.
				Explain that the point already there is the vanishing point.		"Because that is the vanishing point."	None	No	None	
				Decide to call it "perspective lines".		"Yea let's just call it that."	None	No	None	
Donell	The trees are the same size, and look different because of how far you are from them.	Same as before, with more written explanation in the answers to the questions.	1:50	Decide the trees are the same size because you are closer to the front one.	Worksheet	"I said yes because the closer you are to it the bigger things look. "	None	No	None	
				The second tree and house look smaller because they're further away.		"But the only reason why the second tree and house look smaller is because they are further away."	None	No	None	

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First, we used what was visible at the beginning of the clip to determine what the initial slide in the animation would be. At the beginning of the clip, Stephanie is addressing the figure of the houses, one of which has a line missing that she remarks about. Her visual evidence to support this conclusion is pointing at the line. While she verbally claimed that a line was missing, the visual evidence of which line is necessary to retain the window into Stephanie's thinking. This required a new slide showing Stephanie pointing to this line. Then, when Cassie uses appearance to determine the larger tree, she claims, "But this tree does seem bigger than this one." Again, the window into her thinking decreases if we do not know which tree she is referring to. However, because there was a slide added directly before and after this comment, we chose to modify the script to retain the window, replacing "this tree" with "the front tree". In the next operation, Stephanie again points to indicate which line she is referring to, so we recommended a slide showing her pointing to the lines she was referring to. Stephanie does not show visual evidence in the next two operations, so no modifications were necessary to retain the window of those operations. However, in the next operation, she asks what to call the vanishing point by referring to it as "this" and pointing, so we added a slide of her pointing at the vanishing point. In the next two operations, she explicitly describes her thinking, and the script is sufficient to provide a window into her thinking. The final conception of the video, from Donell, is a case where the script does not provide a clear window into his thinking when he says, "I said yes because the closer you are to it the bigger things look." However, in the video, Donell does not show any visual evidence of what "it" is, so adding a modification to the slides or script would provide a greater window into his thinking than was shown in the original clip. The same is true with his final comment. As a result, no slides were added to show Donell's thinking.

Challenges in the Process of Representing Videos as Animations

Explaining clips vs. working clips. During the process of representing video clips as animations, we encountered two main types of challenges, challenges with the clip as a whole and challenges with individual operations. In terms of the clip as a whole, we found two main categories of clip, explaining clips and working clips. Explaining clips were those where the students were explaining their thinking to each other, such as the example above, whereas working clips were those where the students were working on new ideas. Some clips included both explaining and working.

Challenges with explaining clips. In general, explaining clips went smoothly using the process we previously described. These clips showed one student describing one conception with one set of visual evidence at a time, and students typically provided verbal evidence to describe their thinking. Most of the modifications we made involved adding slides or making small changes to the script in order to retain the window when students used vague language like "it" or "this one". The main challenges with explaining clips were difficulties representing certain individual operations in the animation.

In an explaining clip, it was difficult to represent when a student showed their work to another student, rather than specifically describing the actions they performed. In these cases, we chose to create a slide showing the student's work. We chose not to add a verbal description to the script because a verbal description would provide a higher window into students' thinking than the exclusively visual evidence provided in the original video clip. A second challenge was when students referred to multiple quantities in the video clip, but were either not specific about the quantities or specified by pointing. In this case, we had two options; to either add a visual slide showing the student pointing, or change the script to add a verbal description. We considered which modification would least affect the window and clarity of the original clip. For example, in Stephanie's first conception above, she is referring to a specific line on the paper, but there was no easily identifiable name for the line and it was the first new slide in the animation, so we chose to create a slide showing her pointing at the line. On the other hand, in Cassie's first conception, she is

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referring to one of two trees and adding the word "front" to clarify which tree she referred to only modified one word of the script.

Challenges with working clips. Working clips were more challenging to represent as animations because of the nature of the entire clip, rather than challenges with individual operations. Working clips typically showed students independently working on different conceptions simultaneously, students spoke less, and each student showed different visual evidence for their own conception. One adaptation we made to the process for a working clip was to analyze the clip one student at a time, rather than analyzing the conceptions sequentially. This allowed us to remain consistent with the template by examining one conception at a time. After analyzing each individual student, we integrated slides showing the progression of all three students' conceptions back together as close to the original clip as possible.

One challenge in working clips was when a student did mathematical work without explicitly describing it. In some cases, the same clip showed students explaining their operations later. In these cases, we chose to include the explanation of the operations in the animation rather than the student working silently. This allowed the students' thinking to be shown in the video without repeating the same conception, while also retaining the clarity from the original video clip. If the student did not describe the work later, we showed visual slides representing the work without modifying the script. This remained consistent with the original video, where viewers needed to watch the student work on the problem without verbal evidence of what was being done.

Conclusion

Videos and animations have both been used to elicit teacher noticing of students' thinking (Chieu, Herbst, & Weiss, 2011; van Es & Sherin, 2010). Because researchers have found that teachers are able to notice similarly across different representations of students' thinking (Herbst & Kosko, 2014), and due to the ability of animations to reach a wider audience and represent a more general classroom (Chazan & Herbst, 2012), we designed a process to represent video clips we showed in a video club as animations. We found two types of video clips: explaining clips and working clips. While we were typically able to represent an explaining clip as an animation by following the process we designed, we addressed challenges with individual student operations that did not provide enough evidence to retain the window or clarity of students' thinking by making small changes to the script or adding slides to show visual evidence. Working clips were more challenging to represent as animations due to the lack of verbal evidence given by students while working. However, we were able to adapt the process of representing video clips as animations by examining each student individually, making recommendations for what visual evidence would be necessary to retain the window into students' thinking, and integrating the students' conceptions together as slides. Overall, using the dimensions of window and clarity allowed us to both consistently choose whether and when to adapt the script or create visual slides while also ensuring we avoided providing too much evidence in the animation and reducing the ability for teachers to notice student thinking themselves. Further work could compare teachers' reactions to video clips and animations of the same interaction. We believe this work is useful to researchers and designers of professional development as a process for creating animations from video clips in order to increase the number of uses of video clips, create animations that are as realistic to the original video clip as possible, and widen the audience for sharing examples of students' thinking.

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